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Observing brown dwarfs in the Magellanic Cloud star-forming regions with the E-ELT

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Abstract

We present the results of near-infrared imaging simulations of young star-forming regions in the Magellanic Clouds to be observed with the European Extremely Large Telescope (E-ELT). The simulated J, H, K -band images show that we should be able to obtain nearly complete samples of young brown dwarfs above the deuterium burning limit ($M > 13 M_{Jup}$) in low-mass star-forming regions in the Clouds. Moreover, very young giant planet-mass objects in the Clouds should be detectable with the E-ELT under favourable conditions.

1 Magellanic Cloud brown dwarfs in the E-ELT Design Reference Mission

One of the projects proposed as part of the E-ELT Design Reference Mission (DRM) is the determination of the low-mass luminosity function down to the giant planet-mass regime in low-metallicity star-forming regions of the Large Magellanic Cloud (LMC, $[Fe/H] = -0.33$ dex) and the Small Magellanic Cloud (SMC, $[Fe/H] = -0.75$ dex, Romanillo et al. 2008). Typical low-mass star-forming regions of the solar neighborhood, such as Lupus 3 or ρ -Ophiuchi, would subtend an angle of $\sim 2''$ at the distance of the Clouds, thus being appropriate for Laser Tomography Adaptive Optic (LTAO) observations, which would provide nearly diffraction-limited, deep near-infrared (NIR) imaging of the whole stellar and substellar content of the cluster. In order to explore the detectability of the lowest-mass objects we simulate very young clusters similar to those found in the solar vicinity, without massive stars ($M < 2 M_\odot$) able to significantly ionize the gas, as this would dramatically increase the NIR background brightness via free-free emission. The challenge of the observations is the high density of objects (~ 20 objects/arcsec 2) and the fact that the members of the star-forming region cover a wide range in magnitudes, from $K \sim 18$ to $K \sim 30$ mag.

We simulate J, H, K -band images assuming different zenith distance values, in order to assess how much the location of the telescope will influence the observations, and differ-

ent instrument pixel scales and stellar densities. We assume a distribution of stellar masses drawn from Chabrier (2003) initial mass function truncated at $2 M_{\odot}$. Stars are randomly distributed over the $2'' \times 2''$ extent of the cluster and masses are transformed to J, H, K absolute magnitudes using a $t = 5$ Myr isochrone from Baraffe et al. (2003). A distance modulus of 18.5 mag is added plus a random extinction for each star. Variable background is introduced in some cases. All the simulations are performed adopting the technical assumptions of the official DRM data base (http://www.eso.org/sci/facilities/eelt/science/drm/tech_data). Fig. 1 shows a composite J, H, K simulated image of a young star-forming region in the LMC.

We then perform crowded field photometry on the simulated images and compare the recovered luminosity function with the input one, in order to verify if giant planet-mass objects can be detected and measured with sufficient accuracy, i.e. $S/N > 5$ (see Fig. 2).

2 Conclusions

Our simulations show that nearly complete samples of young brown dwarfs above the deuterium burning limit ($M > 13 M_{Jup}$) can be obtained in the Magellanic Cloud low-mass star-forming regions with E-ELT, and even giant planet-mass objects may be detected if the cluster nebulosity is sufficiently faint.



Figure 1: Composite J, H, K -band image of a low-mass star-forming region in the LMC, as observed with E-ELT and LTAO. 100 objects are simulated with masses in the range $5M_{Jup} < M < 2M_{\odot}$, randomly distributed in a field of view of $2'' \times 2''$ (0.5 pc \times 0.5 pc).

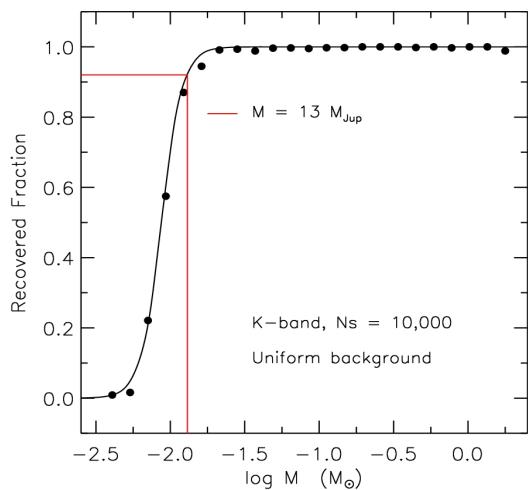


Figure 2: Recovered fraction of stars versus the input mass in steps of $0.12 M_{\odot}$. The completeness function is overplotted as a solid line. The red line indicates the deuterium burning limit, $M = 13 M_{Jup}$, where the recovered fraction of objects is $\sim 90\%$.

References

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